

(12) **United States Patent**  
**Challoner et al.**

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(54) **CLOVERLEAF MICROGYROSCOPE WITH  
ELECTROSTATIC ALIGNMENT AND  
TUNING**

FOREIGN PATENT DOCUMENTS

WO 9745702 4/1997

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(57) **ABSTRACT**

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**Related U.S. Application Data**

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filed on Aug. 9, 2001, now abandoned.

(51) **Int. Cl.**  
**G01C 19/00** (2006.01)

(52) **U.S. Cl.** ..... 73/1.77; 73/504.02; 73/504.04

(58) **Field of Classification Search** ..... 73/1.37,  
73/1.38, 514.15, 504.04, 514.29, 1.77, 504.02  
See application file for complete search history.

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A micro-gyroscope (10) having closed loop output operation  
by a control voltage ( $V_{ty}$ ), that is demodulated by a drive  
axis (x-axis) signal  $V_{thx}$  of the sense electrodes (S1, S2),  
providing Coriolis torque rebalance to prevent displacement  
of the micro-gyroscope (10) on the output axis (y-axis)  
 $V_{thy} \sim 0$ . Closed loop drive axis torque,  $V_{tx}$  maintains a  
constant drive axis amplitude signal,  $V_{thx}$ . The present  
invention provides independent alignment and tuning of the  
micro-gyroscope by using separate electrodes and electro-  
static bias voltages to adjust alignment and tuning. A quadra-  
ture amplitude signal, or cross-axis transfer function peak  
amplitude is used to detect misalignment that is corrected to  
zero by an electrostatic bias voltage adjustment. The cross-  
axis transfer function is either  $V_{thy}/V_{ty}$  or  $V_{mx}/V_{tx}$ . A quadra-  
ture signal noise level, or difference in natural frequencies  
estimated from measurements of the transfer functions is  
used to detect residual mistuning, that is corrected to zero by  
a second electrostatic bias voltage adjustment.

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**16 Claims, 3 Drawing Sheets**

